

Development of innovative controls algorithms for complex façade systems

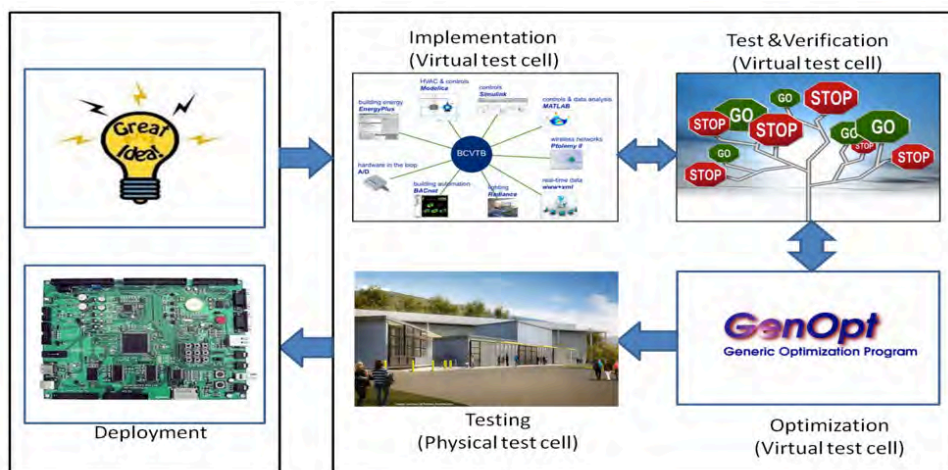
Although there exist a large number of complex façade systems for reduction of solar heat gains in buildings, there is still a lack of innovative control algorithms capable of delivering high-quality, low-energy solutions.

Starting Point

A controls company approaches LBNL with an idea to evaluate and optimize an innovative control algorithm for active façades before commercialization and deployment.

The controls engineer verifies the correct operation of the control algorithm, offline, in a computer-model of a test cell. Since validated Modelica models for each test cell are available, one only needs to implement the controls algorithm for performance verification. The model is then used to further improve the algorithm, running annual simulations in a minute's time, thus allowing for multiple design iterations. Once the algorithm performs satisfactorily in simulation, the controls engineer automatically generates C code from the Modelica model

to implement on actual control hardware. LBNL developed software is then used to link the control hardware to the computer model of the desired test cell. This real-time implementation of physical hardware may have communication delays and signal quantification errors that were not part of the simulation model. Once the



A computer-based virtual testbed is part of the available FLEXLAB resources. This virtual testbed incorporates Modelica models as software for implementation, testing, verification and optimization of innovative controls algorithms for complex facade systems.

test implementation is successful, a three-months field performance test is conducted, in which the algorithm controls the façade systems of the physical test cell. The experiment is analyzed in real-time and compared to simulated reference data to identify and correct possible experimentation. Using physical measurements, the model is recalibrated and used to assess economic and energy benefits across different climate zones. Finally, the algorithm is commercialized, and results from the measurements are used to illustrate and explain the performance of the algorithm to customers.

Testbed Capabilities	Performance Parameters and Benefits
Buildings simulation models	EnergyPlus/Modelica/Radiance tools to model control strategies, lighting/HVAC, and whole “testbed” energy use
Hardware-in-the-loop simulation tools	Virtual test-bed to link different simulation tools during run-time and link simulation tools with real hardware
HVAC control and energy use	Zonal load measurement
Robust data acquisition system to accommodate additional instrumentation	Flexibility to integrate experiment-specific measurement hardware with existing testbed instrumentation

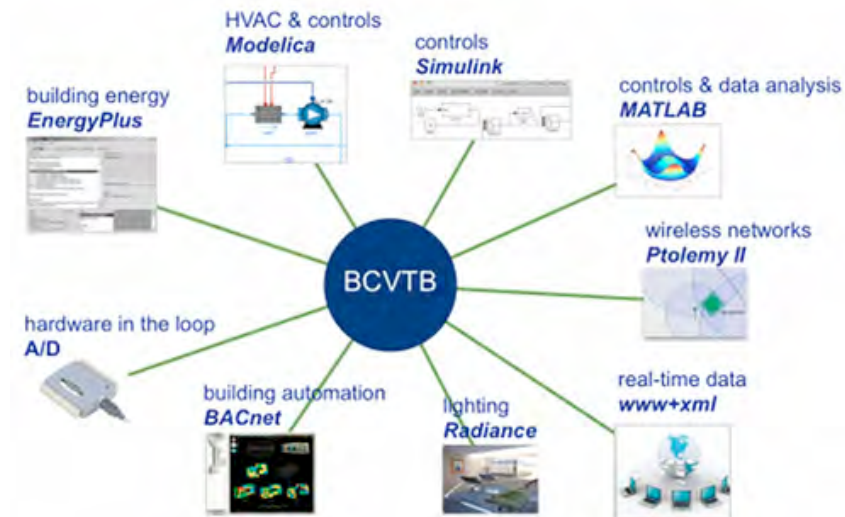
Immediate Outcomes

- Developed and optimized control algorithms for active façades that achieve energy savings in buildings.
- Holistic archival set of high-quality field-measured data for use in manufacturer documentation and publications.
- Test-bed results and information to adjust system control logic, or component performance, if energy or comfort performance is lower than target.

- Use the virtual testbed to conduct optimization in virtual environment prior to time-consuming full-scale testing.
- Use the virtual testbed for hardware-in-the-loop simulation for verification and real-time monitoring.

Extended Validation & Deployment Opportunities

- Use of field-measured data and virtual testing to simulate and extrapolate findings to diverse climates, room geometries, envelope types, HVAC systems, and whole-building performance.
- Partner with LBNL researchers with subject matter expertise.



Integration of various modeling software for developing and testing control algorithms in the virtual testbed prior to testing in the physical testbed.

References and Further Reading

Wetter, M, Zuo, W, Noudui, TS. Modeling of Heat Transfer in Rooms in the Modelica “Buildings” Library. Proc. of the 12th IBPSA Conference, p. 1096-1103. Sydney, Australia, November 2011.

Noudui, TS, Wetter, M, Li, Z, Pang, X, Bhattacharya, P, and Haves, P. BACnet and Analog/Digital Interfaces of the Building Controls Virtual Test Bed. Proc. of the 12th IBPSA Conference, p. 294-301. Sydney, Australia, November 2011.

Wetter, M. Co-simulation of building energy and control systems with the Building Controls Virtual Test Bed. *Journal of Building Performance Simulation*, 4(3):185-203, 2011. Available from: <http://dx.doi.org/10.1080/19401493.2010.518631>

Wetter, M. Modelica-based Modeling and Simulation to Support Research and Development in Building Energy and Control Systems. *Journal of Building Performance Simulation*, 2(2):143-161, 2009. Available from: <http://dx.doi.org/10.1080/19401490902818259>